CLAIMS

1. A photo-detector with a reduced G-R noise, comprising a sequence of a p-type contact layer, a middle barrier layer and an n-type photon absorbing layer, said middle barrier layer having an energy bandgap at least twice that of the photon absorbing layer, there being no layer with a narrower energy bandgap than that in the photon-absorbing layer, wherein under flat band conditions the valence band edge of the contact layer lies below its own conduction band edge, or below the conduction band edge of the barrier layer, by at least twice the bandgap energy of the photon absorbing layer and, wherein when biased with an externally applied voltage, the bands in the photon absorbing layer next to the barrier layer are flat or accumulated, and the flat part of the valence band edge of the photon absorbing layer lies below the flat part of the valence band edge of the contact layer and it also lies an energy of not more than $10kT_{op}$ above the valence band edge in any part of the barrier layer, where k is the Boltzman constant and T_{op} is the operating temperature.
2. A photo-detector according to claim 1 wherein the photon absorbing layer has a typical thickness of 1-10μ and doping of $n < 10^{16}$ cm^{-3}.
3. A photo-detector according to claim 1 wherein the middle barrier layer has a thickness of between 0.05 and 1μm.
4. A photo-detector according to claim 1 wherein the barrier layer is doped n-type, typically $n < 5 \times 10^{16}$ cm^{-3}, and a p-n junction is formed between said barrier layer and a p-type, $p < 5\times10^{18}$ cm^{-3}, contact layer.
5. A photo-detector according to claim 1 wherein the barrier layer is doped p-type, typically $p < 5 \times 10^{16}$ cm^{-3} and a p-n junction is formed between said

barrier layer and an n-type δ–doping layer typically with $5\times10^{10} < n < 10^{12}$ donors cm^{-2} included at the edge of the photon absorbing layer next to the barrier layer.

6. A photo-detector according to claim 1 wherein the barrier layer is low-doped p-type, typically $p < 10^{15}$ cm^{-3}, and a p-n junction is formed between said barrier layer and the n-type photon absorbing layer.

7. A photo-detector according to claim 1, wherein the photon absorbing layer is an $InAs_{1-x}Sb_x$ alloy.

8. A photo-detector according to claim 1 wherein the photon absorbing layer is a type II superlattice material which comprises alternating sub-layers of $InAs_{1-w}Sb_w$ and $Ga_{1-x-y}In_xAl_ySb_{1-z}As_z$ with $0\leq w \leq1$, $0\leq x \leq1$, $0\leq y \leq1$, $0\leq z \leq1$ and $x + y <1$ and wherein the sub-layers each have a thickness in the range of 0.6-10 nm.

9. A photo-detector according to claim 1 wherein the contact layer is GaSb.

10. A photo-detector according to claim 1, wherein the contact layer is a type II superlattice comprising alternating sub-layers of $InAs_{1-w}Sb_w$ and $Ga_{1-x-y}In_xAl_ySb_{1-z}As_z$ with $0\leq w \leq1$, $0\leq x \leq1$, $0\leq y \leq1$, $0\leq z \leq1$ and $x + y <1$ and wherein the sub-layers have a thickness in the range of 0.6-10 nm.

11. A photo-detector according to claim 1 wherein the middle barrier layer is a $Ga_{1-x}Al_xSb_{1-y}As_y$ alloy with $0\leq x \leq1$ and $0\leq y \leq1$.

12. A photo-detector according to claim 1 in which the n-type photon absorbing layer is terminated by a highly n-doped terminating layer, typically with 3 ×

$10^{17} < n < 3 \times 10^{18}$ donors cm^{-3}, and with thickness 0.5 - 4μ, so that the valence band edge of said highly n-doped terminating layer lies below that of the n-type photon absorbing layer.

13. A photo-detector comprising stacked detector sub-units as in claim 7 in which each detector sub-unit may have a different cut-off wavelength and in which each detector sub-unit is separated from its neighboring sub-unit by a p-type GaSb layer to which an external contact may be made.

14. A photo-detector with a reduced G-R noise, comprising a sequence of a p-type contact layer, a middle barrier layer and an n-type photon absorbing layer, said middle barrier layer having an energy bandgap significantly larger than that of the photon absorbing layer, there being no layer with a narrower energy bandgap than that in the photon-absorbing layer, wherein under flat band conditions the valence band edge of the contact layer lies below its own conduction band edge, or below the conduction band edge of the barrier layer, by significantly more than the bandgap energy of the photon absorbing layer and, wherein when biased with an externally applied voltage, the bands in the photon absorbing layer next to the barrier layer are flat or accumulated, and the flat part of the valence band edge of the photon absorbing layer lies below the flat part of the valence band edge of the contact layer and it also lies an energy of not more than $10kT_{op}$ above the valence band edge in any part of the barrier layer, where k is the Boltzman constant and T_{op} is the operating temperature.

15. A photo-detector according to claim 14 wherein the photon absorbing layer has a typical thickness of 1-10μ and doping of $n < 10^{16}$ cm^{-3}.

16. A photo-detector according to claim 14 wherein the middle barrier layer has a thickness of between 0.05 and 1μm.

17. A photo-detector according to claim 14 wherein the barrier layer is doped n-type, typically $n < 5 \times 10^{16}$ cm^{-3}, and a p-n junction is formed between said barrier layer and a p-type, $p < 5 \times 10^{18}$ cm^{-3}, contact layer.

18. A photo-detector according to claim 14 wherein the barrier layer is doped p-type, typically $p < 5 \times 10^{16}$ cm^{-3} and a p-n junction is formed between said barrier layer and an n-type δ–doping layer typically with $5 \times 10^{10} < n < 10^{12}$ donors cm^{-2}, included at the edge of the photon absorbing layer next to the barrier layer.

19. A photo-detector according to claim 14, wherein the photon absorbing layer is InSb or an $In_{1-x}Al_xSb$ alloy.

20. A photo-detector according to claim 14 wherein the contact layer is InSb or an $In_{1-x}Al_xSb$ alloy.

21. A photo-detector according to claim 14 wherein the middle barrier layer is an $In_{1-x}Al_xSb$ alloy.

22. A photo-detector according to claim 14 in which the n-type photon absorbing layer is terminated by a highly n-doped terminating layer, typically with $3 \times 10^{17} < n < 3 \times 10^{18}$ donors cm^{-3}, and with thickness 0.5 - 4μ, so that the valence band edge of said highly n-doped terminating layer lies below that of the n-type photon absorbing layer.

23. A photo-detector with a reduced G-R noise, comprising a sequence of a n-type contact layer, a middle barrier layer and a p-type photon absorbing layer, said middle barrier layer having an energy bandgap significantly more than and preferably at least twice that of the photon absorbing layer, there being no layer with a narrower energy bandgap than that in the photon-absorbing layer, wherein under flat band conditions the conduction band edge of the contact layer lies above its own valence band edge or above the valence band edge of the barrier layer by significantly more than and preferably at least twice the bandgap energy of the photon absorbing layer and, wherein when biased with an externally applied voltage, the bands in the photon absorbing layer next to the barrier layer are flat or accumulated, and the flat part of the conduction band edge of the photon absorbing layer lies above the flat part of the conduction band edge of the contact layer and it also lies an energy of not more than $10kT_{op}$ below the conduction band edge in any part of the barrier layer, where k is the Boltzman constant and T_{op} is the operating temperature.
24. A photo-detector according to claim 23 wherein the photon absorbing layer has a typical thickness of 1-10μ and doping of $p < 10^{16}$ cm^{-3}
25. A photo-detector according to claim 23 wherein the barrier layer is doped p-type, typically $p < 5 \times 10^{16}$ cm^{-3}, and a p-n junction is formed between said barrier layer and a n-type, $n < 5\times10^{18}$ cm^{-3}, contact layer.
26. A photo-detector according to claim 23 wherein the barrier layer is doped n-type, typically $n < 5 \times 10^{16}$ cm^{-3} and a p-n junction is formed between said barrier layer and a p-type δ–doping layer typically with $5\times10^{10} < p < 10^{12}$

acceptors cm^{-2}, included at the edge of the photon absorbing layer next to the barrier layer.

27. A photo-detector according to claim 23 wherein the barrier layer is low-doped n-type, typically $n < 10^{15}$ cm^{-3}, and a p-n junction is formed between said barrier layer and the p-type photon absorbing layer.

28. A photo-detector according to claim 23 in which the p-type photon absorbing layer is terminated by a highly p-doped terminating layer, typically with $3 \times 10^{17} < p < 3 \times 10^{20}$ acceptors cm^{-3}, and with thickness 0.5 - 4μ, so that the conduction band edge of the highly p-doped terminating layer lies above that of the p-type photon absorbing layer

29. A photo-detector comprising stacked detector sub-units as in claim 1, in which each detector sub-unit may have a different cut-off wavelength.

30. An array of identical detectors in which each detector is as in claim 1 and is connected to a silicon readout circuit by an indium bump.

31. An array of identical detectors in which each detector may be sensitive to more than one wavelength band as in claim 13, and in which each detector is connected to a silicon readout circuit using one indium bump or using one indium bump per detector sub-unit.